Section 2: Thunderstorms (Initiation and Life Cycle) (Slides 25 through 54)

This is Part 1, Section 2: Thunderstorms, their initiation and life cycle.

In this section, we'll discuss thunderstorm facts and climatology, the ingredients needed for thunderstorm growth, and the thunderstorm life cycle.

Here are the 3 objectives of Section 2. Approximately what percentage of thunderstorms are classified as severe? What are the 3 ingredients needed for thunderstorm development? What are the 3 phases in the thunderstorm life cycle?

At any moment, approximately 2,000 thunderstorms are in progress on Earth. Less than 1% of all thunderstorms are classified as severe, with large hail (3/4 inch diameter or greater) or damaging winds (58 mph or greater). In the U.S. the Florida Peninsula and the southeastern plains of Colorado have the highest thunderstorm frequency. The highest thunderstorm frequency in the world occurs in portions of equatorial Africa.

Now let's move on and talk more in depth about how thunderstorms form. Just like making a casserole for dinner, there are certain ingredients in the atmosphere that are needed for thunderstorms to form. There are three needed for thunderstorm development. These are: Moisture, Instability and Lift.

Moisture is perhaps the most important ingredient in thunderstorm development, or precipitation development in general. Without moisture, it's hard to get the atmosphere to rain! One of the basic concepts in meteorology is the phenomenon of condensation. As air rises in a thunderstorm updraft, moisture condenses. When moisture condenses, heat is released in to the air, making it warmer and less dense than its surroundings. This added heat allows the air in the updraft to continue rising. The most predominant moisture sources for thunderstorms in the eastern United States come from the western Atlantic Ocean, and from the Gulf of Mexico.

The second ingredient needed for thunderstorm development is instability, or buoyancy in the atmosphere. If the airmass is unstable, air which is pushed upward will continue upward. An unstable airmass usually contains relatively warm (usually moist) air near the surface and relatively cold (usually dry) air in the mid and upper levels of the atmosphere. As the low-level air rises it becomes less dense than the surrounding air and will continue to rise. The air will continue rising until it becomes colder and more dense than the surroundings. On the flip side, if the atmosphere is stable, air which is pushed upward will tend to sink back downward to its original position. If broad stability exists in the atmosphere, then thunderstorms aren't as likely to form even if other favorable ingredients are present.

Lift is a mechanism for starting an updraft in a moist, unstable airmass. The lifting source can take on several forms, including orographic (air forced up a mountain) and advancing fronts (cold front, sea-breeze front, etc.). Another common source is differential heating. This occurs when portions of the area are heating more than other areas (sunny vs. cloudy areas). The warm pockets are less dense than the surrounding air and will rise. The main point here is that you need a way to get the air to rise. Unless the air is extremely unstable, it usually needs some sort of kick to get it moving upwards. Mountains and fronts are two of the most common examples.

There are three phases in a thunderstorm's life cycle. These are the cumulus stage, the mature stage, and the dissipation stage. Critical processes of development and decay occur during these stages, all of which are important in determining how the storm evolves, and how strong it becomes.

The first stage in thunderstorm development is the cumulus cloud, or cumulus stage. Although most cumulus clouds do not become thunderstorms, the initial stage of a thunderstorm is always a cumulus cloud. The chief distinguishing feature of this cumulus or building stage is an updraft, which prevails throughout the entire cell. Such updrafts vary from a few feet per second in the early cells to as much as 100 feet per second in mature cells. In the cumulus stage, the updraft develops and precipitation is produced in the upper portions of the storm. As the precipitation begins to fall out of the storm, a downdraft is initiated.

The second stage in thunderstorm development is known is the mature stage. The beginning of surface rain, with adjacent updrafts and downdrafts, initiates the beginning of this stage. By this time, the top of the average thunderstorm cloud, or cell has attained a height of 25,000 feet or more. As the raindrops begin to fall, the frictional drag between the raindrops and the surrounding air causes the air to begin a downward motion. As this air continues to sink downward, the rate of motion is accelerated, resulting in a rain-cooled downdraft. At this stage, the cloud takes on the classic towering cauliflower appearance with sharp, well defined edges. Again, the mature stage is characterized by a co-existence of an updraft and a downdraft in the storm. When the downdraft and rain-cooled air reach the ground, the rain-cooled air spreads out along the ground and forms the gust front.

Eventually, a large amount of precipitation is produced and the storm becomes dominated by the downdraft. At the ground, the gust front moves out a long distance from the storm and cuts off the storm's inflow/updraft. This begins the dissipating stage of the thunderstorm. This stage usually occurs rather quickly, approximately 20-30 minutes into the life of the thunderstorm. The downdraft will push down out of the thunderstorm, hit the ground and spread out. The cool air carried to the ground by the downdraft cuts off the inflow of the thunderstorm, the updraft disappears and the thunderstorm will begin to dissipate. At this stage, the top of the thunderstorm cloud will often flatten, spread out and take the shape of an anvil, with the sharp edges noted in the mature phase becoming fuzzy and less-

defined. The flattening is a result of the cloud top reaching the stable layer at the top of the lower atmosphere known as the tropopause. The tropopause marks the boundary between the troposphere, or lower atmosphere, and the stratosphere above. The fuzzy appearance of the upper portions of the thunderstorm cloud is due to water turning into ice crystals in the colder sub-freezing air at the top of the cloud.

This completes Part I, Section 2, Thunderstorm initiation and life cycle. In this section we discussed some basic thunderstorm climatology, noting that approximately 2,000 thunderstorms are ongoing at any given moment on the Earth's surface, and less than 1% of all thunderstorms are classified as severe. We also talked about the 3 ingredients needed for thunderstorm development, moisture, instability, and lift, and why they're necessary for storm growth and development. Finally, we discussed the 3 stages in the thunderstorm life cycle, cumulus, mature, and dissipating, and the storm characteristics during each. At this time, you may stop the training, or proceed to Part 1, Section 3, Thunderstorm Types.